Journal of the Midwest Association for Information Systems (JMWAIS)

Volume 2019 | Issue 1 Article 3

2019

Building a Shared Understanding of Female Participation in IT through Collaboration: A Shared Mental Model Approach

Gaye L. Kiely
University College Cork, gaye.kiely@ucc.ie

Ciara Heavin
National University of Ireland, Cork, c.heavin@ucc.ie

Patricia Lynch
University College Cork, PLynch@ucc.ie

Journal of the Midwest Association for Information Systems

Volume 2019 | Issue 1 Article 3

Date: 01-31-2019

Building a Shared Understanding of Female Participation in IT through Collaboration: A Shared Mental Model Approach

Gaye Kiely
University College Cork, Gaye.Kiely@ucc.ie

Ciara Heavin
University College Cork, c.heavin@ucc.ie

Patricia Lynch
University College Cork, PLynch@ucc.ie

Abstract

Information Technology has never been more pervasive and accessible, yet decreasing female participation in the field (and the variety of reported causes) presents a 'wicked problem' for IT educators and professionals. In this article, we suggest that female students' decision-making is adversely impacted by an inaccurate, shared understanding of IT. Subsequently, the problem of low female participation in IT requires a practical, collaborative solution. Employing an abductive research approach, we undertook a qualitative, exploratory study of female-only schools in Ireland using the #MakeITWork programme. During this multi-phased programme, we conducted (i) focus groups to explore female students' perception of IT undergraduate degree programmes and careers; (ii) knowledge exchange (KX) sessions to communicate IT degree and career opportunities; and (iii) a survey to assess the efficacy of the approach in changing perceptions. Data analysis revealed that a new accurate shared mental model (SMM) was needed to support female students' education decisions. This facilitated theory development with respect to female students' decision to pursue IT education and careers. Study findings indicate that while attitudes towards IT careers are largely outdated, these views can be changed through a collaborative intervention workshop approach. This can be achieved through greater stakeholder collaboration and better quality information available via novel formats.

Keywords: Education, Inclusion, Gender, Information Technology (IT), Awareness, Careers, Knowledge Exchange (KX) and #MakeITWork.

DOI:1017705/3jmwa.000046

1. Introduction

Female participation in science and engineering has been steadily increasing across industrialized countries (Anderson, Lankshear, Timms, & Courtney, 2008). However, this upward trend does not hold true for Information Technology (IT) graduates. Since the late 1990s, female IT graduates are declining in numbers in countries such as the USA, Canada, Ireland, Taiwan and Spain (Millar & Jagger, 2001). This decline has been observed among young females taking and successfully completing technology/IT electives in Australian high schools (Victorian Curriculum and Assessment Authority, 2014). In a US-based study, females enrollment is constant in biological, medical and social science fields; nonetheless, a gap remains in the women pursuing engineering, computer science and physical science programmes (Eccles, 2011). Data suggests a diminishing interest among young women in applying for IT courses and in pursuing associated careers (Ashcraft, Eger, & Friend, 2016; Fisher, Lang, Craig, & Forgasz, 2015).

For every thousand women in the EU with a degree, only twenty-nine hold a degree in IT, compared to ninety-five men, and just four of those women will eventually work in the IT sector (European Commission, 2013). In an Irish context, female representation in IT has never been high. In 1998, women accounted for nearly 31 percent of the Irish IT workforce. This number dropped to 27.5 percent in 2004 (Organization for Economic Co-operation and Development, 2007). Eurostat (2014) indicates that in Ireland, females accounted for 45 percent of third level (university) science, mathematics and computing qualification enrolments in 2001. However, this figure declined to 36.8 percent by 2012 (Eurostat, 2014). Yet, career opportunities for IT graduates in Ireland have never been as good. New job opportunities are announced on an almost weekly basis and 44,500 new jobs have been predicted in the Irish IT sector over the next four years (Kennedy, 2014). Organizations are eager to increase female presence in the workplace and have undertaken numerous initiatives to encourage female entry into IT roles (Aperian Global, 2017; Winning, 2018). While studies have focused on understanding the relationship between increased female participation and organization profitability have had various findings, industry leaders believe that increased female presence in the workforce delivers several benefits to organizations (Noland et al., 2016). These assumed benefits include (i) reducing the skills shortage in IT; (ii) creating an attractive work environment for millennials; (iii) increasing employee engagement due to the presence of female role models; (iv) increasing innovation; and (v) providing a voice for the target market of the organization (Cosgrove, 2015; Intel Decoding Diversity Report, 2016).

There is pressure to engage females in STEM (Science, Technology, Engineering and Mathematics) subjects and to improve gender diversity in global international organizations (Accenture, 2017). This pressure has created a strong rationale for both educators and employers to better understand young females' decision-making with respect to IT education and related careers. This, in turn, has motivated researchers to explore the decision-making process engaged in by females when selecting education and career paths. While existing research has highlighted the barriers to female participation (Siann & Callaghan, 2001), relatively few studies have focused on the use of interventions in this decision-making process. Existing research examines the factors influencing IT gender gap separately, such as individual, family and social factors e.g. Anderson et al., 2008; Drabowicz, 2014; Fisher et al., 2015. Through a more holistic approach comprising these factors, the objective of this study is to develop a theory that will provide an improved understanding of the shared perception of IT as an area of study and a potential career choice, and the role that collaborative interventions can play in addressing these perceptions. To the best of our knowledge, theory building in this domain has been limited to date. We use Shared Mental Models (SSM) as a theoretical lens to investigate young females' understanding of IT-related undergraduate degree programmes and the opportunities afforded to graduate students who have IT skills. We undertook an abductive research process to pursue an exploratory, qualitative analysis. We undertook a phased strategy to further examine this phenomenon.

This article is structured as follows: the next section presents a review of relevant literature relating to young womens' engagement with formal IT education as a means of investigating those factors that impact the trend of females opting for alternative courses/majors and career paths. The motivation for the study is presented and the research approach adopted by the researchers is explained. Then the results from the collaborative intervention (workshop) are recounted and the survey results are reviewed. Theory matching and data analysis lead to a conceptual model and propositions. The article concludes with a discussion of the findings, and presents implications for both research and practice.

2. Factors influencing the selection of IT Degrees and IT Careers among Young Females

Academics and practitioners continue to search for new ways to attract greater numbers of females to IT degrees and subsequently to IT-related careers (Wang & Degol, 2013). Existing research considers the perceived barriers or disincentives to choosing IT (Ahuja, 2002; Anderson et al., 2008; Fisher et al., 2015). A significant number of females are disinterested in computers, or find the idea of working with computers boring (Anderson et al., 2008). Empirical evidence indicates that this number remains in sharp decline on an annual basis (Eurostat, 2014) despite the proliferation of media campaigns and female only training for young software developers e.g. digital divas (Fisher et al., 2015). However, the protestation that "computers are boring" is (Anderson et al., 2008) unconvincing when female technology-spending and recreational technology use rivals that of male counterparts (Drabowicz, 2014). Given the heavy investment the IT industry has made to promote a diversified workforce and the diverse range of IT roles and career paths that may be pursued, the continuing low female participation in the industry is surprising. We posit that new research is warranted to further understand the low female engagement phenomenon.

Existing research places considerable emphasis on three factors; namely 1) gender stereotypes, 2) awareness and 3) ability. These factors are recognized to influence the uptake of IT degrees and subsequently IT careers amongst young females (Figure 1). Focusing on these three factors together will amount to a more holistic approach to engaging with the challenge of low female participation in IT.

GENDER STEREOTYPES societal and/or structural contexts that influence one's view of the world (Eccles et al., 1999; Ahuja, 2002; Beyer et al, 2002; Margolis & Fisher, 2002; Trauth, 2006; Adya & Kaiser, 2005; Papastergiou, 2008; Trauth, 2013; Wang & Degol, 2013; Fisher et al., 2015)

AWARENESS of IT and IT career opportunities (von Hellens et al., 2004; Adya & Kaiser, 2005; Anderson et al., 2008; Papastergiou, 2008; Wang & Degol, 2013)

Personal **ABILITY** to succeed (Eccles et al., 1999; Beyer et al., 2002; Leever et al., 2002; Gurer & Camp, 2002; Adya & Kaiser, 2005; Cisco Systems, 2004; Papastergiou, 2008; Leiviskä, 2010; Eccles, 2011; Wang & Degol, 2013)

Figure 1. Factors influencing the uptake of IT Degrees/Careers among Young Females

The disconnect between positive representations of IT career opportunities and female choices in related third level (university) qualifications needs to be resolved (Ashcraft, Eger, & Friend, 2012). Figure 1 presents existing Information Systems (IS)[1] research that considers the topic of gender IS specifically focusing on female engagement with IT education and IT careers across three key factors.

[1] Information Systems (IS) are arrangements of people, data, processes, and information technology that interact to collect, process, store, and provide as output the information needed to support an organisation, Information Technology (IT) is the combination of computer technology (hardware and software) with communications technology.

2.1 Gender Stereotypes

The gender factor is core to female participation in IT (Trauth, 2013). Several research studies have revealed a gender imbalance in IT (Adya & Kaiser, 2005; Ahuja, 2002; Beise, Myers, VanBrackle & Chevli-Saroq, 2003; Trauth, Nielsen & von Hellens, 2003). Career genderization occurs early in an adolescent's life, possibly in middle school or the early years of high school (Adya & Kaiser, 2005). This genderization is likely to grow, resulting in a female's negative perceptions about their ability to succeed in more technical fields of study and work (Beyer, Rynes, Perrault, Hay & Haller, 2002). Core to the discussion about gender and IT, Trauth (2006, p1154) suggests there are two main theories: first, essentialist theory presupposes the existence of relevant differentiators between men and women including their respective attitudes to IT. Essentially hypothesizing that the female attitude toward IT differs compared to the male attitude. Based on this line of thinking, Trauth, Quesenberry & Morgan (2004) contend that females are underrepresented in IT as a result of biology. The second theory focuses on social construction (Adya & Kaiser, 2005; Trauth, 2006). This theory considers the societal impact, characterizing IT as "men's work" places IT careers outside the domain of women" (Trauth, 2006, p1155) supporting Margolis & Fisher's (2003) view that the societal perception of IT as a field of employment was 'male-gendered'. Furthermore, Papastergiou (2008) purports that the declining numbers of young females attracted to careers in IT may be attributed to gender bias in the home environment. Social (i.e. family, friends) and structural (i.e. school) influences are widely cited as determinants on career choices among young females (Ahuja, 2002; Adya & Kaiser, 2005; Fisher et al., 2015).

Trauth (2013) extends these two theories of essentialist and social construction to incorporate a third theory. She suggests that gender theories "fall into three broad categories: gender essentialism, social shaping of gender, and gender intersectionality" (p.284). The third theory of gender intersectionality focuses on the nuance or within-group variability (Trauth, 2013). Adya and Kaiser's (2005) career choice article is one example where intersectionality is theorized based on an investigation of structural factors, social settings, ethnic culture and how these factors influence career choice.

2.2 Awareness

There remains a lack of awareness and understanding about the variety of IT careers (Ridley & Young, 2012). According to Whitten et al. (2004) IT is often used as a blanket descriptor for careers that involve computing and Information Systems (IS). In their research on the nature of IT work, von Hellens et al. (2004) uncovered a prevailing perception that the IT workplace is essentially masculine and this can be unappealing to females. Other research indicates that students are uncertain about the nature of IT work and the skills required to succeed in this field (Anderson et al., 2008). In their study, Anderson et al. (2008) revealed that IT is perceived as difficult, boring, and solitary in nature, requiring little interaction with other people. In fact, Adya & Kaiser (2005, p23) concluded that "the misperception of what IT professionals do and what skills they need to succeed can deter many college students from choosing an IT-related major, and therefore a career in that field." The need for greater awareness of this career domain is acknowledged (Papastergiou, 2008; Ridley & Young, 2012). To achieve this, Adya & Kaiser (2005) recommend that teachers and career guidance counsellors play their part by disseminating appropriate information and support to students, encouraging them to consider IT as a prospective career.

2.3 Ability

Lack of confidence in technical ability remains a challenge for females in both high school (Eccles, 2011; Fisher et al., 2015) and the work place (Eccles, 2011). Often gender stereotyping commences around a young female's math competency compared with the skills of their male counterparts (Beyer et al., 2002). Young females experience low confidence when it comes to their mathematical, physical science (Eccles, Barber, & Jozefowicz, 1999; Leever, Dunigan & Turner, 2002; Leiviskä, 2010) and IT ability (Adya & Kaiser, 2005). Existing research (Gürer & Camp, 2002; Cisco Systems, 2004) indicates that females are intimidated by their male counterparts when it comes to IT subjects. This finding is illustrated in previous studies where young females are characterized by displaying less experience and self-confidence in their own computing skills (Papastergiou, 2008).

Given the reported issues related to recruitment of females to the IT field, such as (i) the perceived genderization of IT education and the IT industry ii) limited awareness of different career paths and opportunities; and (iii) lack of confidence in their mathematical and technical ability, it is critical that researchers explore these factors as they impact third level education and future careers. These three factors highlight the challenging female recruitment IT landscape and the

breadth of contributors in the recruitment of females into IT roles. Studies by Clayton, Beekhuyzen & Nielsen (2012) and Wang & Degol (2013) consider the importance of school, and family contextual factors such as teachers, peers and family members in shaping the academic performance and motivation of young females.

The continuing and almost worldwide shortage of qualified, skilled females for the IT industry means that research focusing on the issues of female recruitment to third level IT programmes is not only timely but critical. The following section outlines the abductive research approach adopted by the researchers to explore these factors and to build a theory around the criticality of developing accurate shared understanding amongst students and key contributors to IT education and career decisions.

3. Research Method

The objective of this research is to develop a descriptive explanatory theory of female student decision-making with respect to IT education and careers. This was achieved using a qualitative approach in the form of a three-phased collaborative intervention workshop. The issue of low female participation in IT education and careers is a 'wicked problem' that continues to challenge students, educators, researchers and industry. We acknowledge that it is the student that ultimately makes the final decision to select an undergraduate degree and a subsequent graduate career path. However, it is widely understood that a team of individuals, including parents, other family members, peers and teachers, provide the student with the information and insights to support them in making these decisions. Given the complexity of the issue, it is important to pursue a creative process that develops new understanding in an attempt to uncover potential solutions to this ongoing problem. As the objective was to discover something novel with respect to female student decision-making for IT education and careers, an abductive approach was proposed. By employing an abductive research approach (Peirce, 1955), the researchers were able to employ prior theoretical knowledge on low female participation in IT as a comparator to real-life observations. This exercise led to a theory matching process wherein theoretical explanations for unexpected phenomenon were derived (Kovács & Spens, 2005). The topic of social inclusion specifically related to the area of gender and IT has long been an area of IS research and theorizing (Trauth, 2003; Trauth et al., 2006). An abductive research approach was deemed a good fit for the study, as it supported the utilization of existing knowledge to understand real-life observations and identify a theory to explain real-life observations (theory matching) and conclude with novel theoretical suggestions in the form of a conceptual model and propositions. Following Kovács & Spens (2005), the study included four distinct phases of research enquiry (see Figure 2).

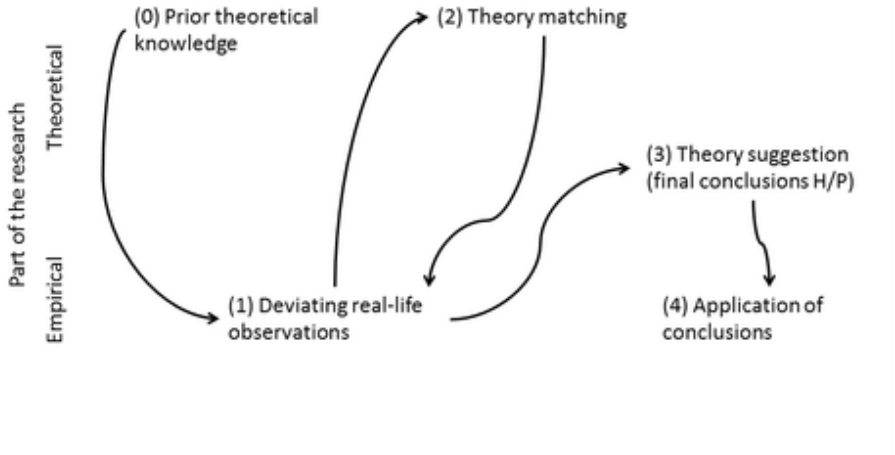

Figure 2. The abductive research process (Kovács & Spens, 2005)

As noted by Carr, Durant & Downs (2004), the abductive research approach is based on pragmatism and action learning. This method of inquiry allows the researchers to extend their understanding of real-life observations and theoretical explanations through an interactive process (Dubois & Gadde, 2002). The #MakeITWork workshop programme was conducted to gain a more intimate appreciation of the research phenomenon under consideration (Van Mannen, 1983). The programme was designed by three IS researchers to investigate the factors associated with choosing IT. The aim of #MakeITWork was to provide richer knowledge to a cohort of female high school students about the

breadth of opportunities in Ireland and internationally for young women with IT skills. The workshop programme included (i) brainstorming; (ii) a knowledge exchange (KX) session; and (iii) qualitative survey. These collaborative intervention workshops were conducted with 109 sixteen-year-old female high school students, their teachers and third-level educators in three female only Irish high schools, during spring and autumn 2014. Each workshop lasted two hours in duration and included three phases (Table 1).

Workshop	Approach	Description	Rationale	Data Source
Phase 1	Brainstorming/ Idea generation session	Edward de Bono's Six Thinking Hats Methodology (1985) used to identify the views and feelings of students for the concept of IT (White – facts, Green – ideas, Black-criticism, Yellow – benefits, Blue – organisation of information, Red – gut feeling)	Understand 'As-Is' - explore the views/perceptions of this cohort of students	Verbal and written group feedback from three classes through focus group approach
Phase 2	Knowledge Exchange Sessions	Knowledge exchange providing an overview of the degree (i.e. Business and IT modules available), undergraduate placement opportunities (i.e. year 3 placement programme) and career opportunities	Intervention – provide a better/richer understanding of one IT-related degree programme and prospective career opportunities	Questions and answers session with students
Phase 3	Qualitative Survey	The ten questionnaire items (Table 2) represent the typical topics raised by school students with respect to IT third-level courses and careers. These questions were derived from fourteen years of school visits, open days and past presentations.	Gauge the impression of Phase 1 and Phase 2 among this cohort of students	109 Completed surveys

Table 1. Overview of #MakeITWork Programme

Phase 1 involved a brainstorming session using the Edward de Bono Six Thinking Hats Methodology (1985), see Figure 3. Through a parallel thinking approach, this idea generation activity provided students with an opportunity to work together to articulate their individual and shared views in an organized manner. This group interaction afforded the researchers an opportunity to initiate "communication between research participants in order to generate data" (Kitzinger, 1995). This level of bi-directional interaction supported the abductive approach prescribed by the study design. Further, Nonaka and Takeuchi (1995) support brainstorming as an enabler for new knowledge, advocating the need to step outside the normal way of thinking, in some cases leveraging external knowledge resources as a means of disrupting existing shared understanding among students in order to generate fresh ideas. The objective of the activity was to work through the six hats in order to elicit student ideas based on the proposition "*What a career in IT means to me?*"

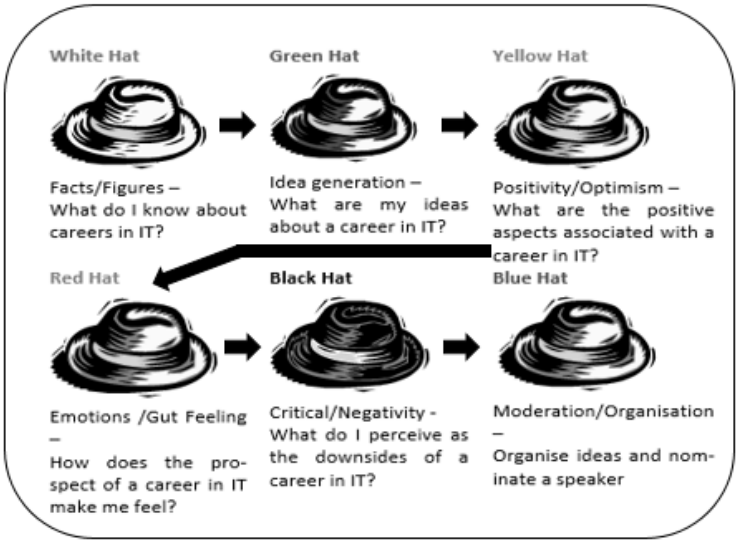

Figure 3. #MakeITWork Six Thinking Hats Methodology

As part of Phase 1, students self-selected into groups of four and were provided with a Six Thinking Hats exercise pack (this included six colored sheets of paper and a set of basic instructions). Each group was invited to assemble their hats from the pack in less than five minutes. Following this, we presented the rationale behind the Six Thinking Hats Methodology for brainstorming and idea generation. Each hat was allocated eight minutes, to facilitate group discussion and note taking using the sequence of hats illustrated in Figure 3. De Bono (1985) recommends a pre-set sequence if the group is unfamiliar with the Six Thinking Hats Methodology. Subsequently, we defined the sequence of hats, i.e. white/green/yellow/red/black/blue, providing the groups with the opportunity to develop a common understanding of the task at hand before offering criticisms (Black hat). During each eight-minute interval, students were supported to engage in parallel thinking. When the final hat, the blue hat was called, each group was asked to organize the output from their group discussion and to nominate a speaker for the group to present the highlights of their findings. These findings were noted by the research team during the session and the notes made by each student team were collected at the end of the collaborative intervention. As part of Phase 2 (illustrated in Table 1), the researchers conducted an hour long knowledge exchange (KX) session at each of the three high schools. These sessions provided the opportunity to inform the students' understanding of the IT field and careers. During this KX, rich insights were provided based on an IT-related degree programme currently on offer. Using freely available presentation software, a thirty-minute overview of this programme was presented including information on first year subjects, placement opportunities and career opportunities in a variety of business sectors. The presentation was followed by an interactive question and answer session where the facilitators and students engaged on questions, comments and feedback that arose from Phase 1 and 2. This bi-directional KX provided students with a better understanding of opportunities while supporting the researchers' need to identify the critical knowledge requirements prohibiting female participation in IT.

Following the KX session, Phase 3 (illustrated in Table 1) the students were asked to complete an exploratory questionnaire. This data collection tool was designed to investigate the three factors illustrated in Figure 1, namely; 1) gender stereotypes, 2) awareness and 3) ability. The questions represent the most common queries raised by secondary school students. Questions were identified and refined by the researchers on the basis of fourteen years' experience of secondary level student outreach efforts (school visits, open days and past presentations, etc.). Using 5 point Likert scales (Table 2), students were instructed to indicate their level of agreement with each question statement. In addition to the ten statements listed in Table 2, a final optional question afforded students the opportunity to provide clarifying comments for their responses to the first ten statements.

ID	Question
1	I have a good understanding of information technology (IT) college courses.
2	I am interested in undertaking an IT qualification after college.
3	I think girls are interested in IT.
4	I believe IT courses are geared towards male students.
5	I have an appreciation for the career possibilities available to someone with an IT qualification.
6	I am aware how much an IT Graduate is paid.
7	I believe that I need to be good at math to be good at IT.
8	I believe that all IT college graduates become programmers.
9	I have sufficient access to IT course information.
10	I believe that an IT course would be too challenging for me.

Table 2. Questionnaire

The questionnaire was piloted with a small sample of sixteen-year-old female students to ensure that it was unambiguous for the intended respondents (Remenyi & Williams, 1995) and it measured the intended items accurately. The results of the pilot were largely consistent, with a few questions requiring rewording. The pilot study also allowed the researchers to estimate survey completion time, improve instructions and navigation. Paper-based questionnaires were distributed at the end of the #MakeITWork session. Three collaborative interventions resulted in 109 completed and valid questionnaires. Data was manually inputted to MS Excel for data analysis.

Data collected during Phase 1 was analyzed on a hat-by-hat basis triangulating the sentiment of the hats with the group responses. This exploratory analytic approach provided rich insights and knowledge from the qualitative data collected from students allowing us to delve deeper into the phenomenon (Komori, 2017). We conducted a thematic analysis of the data which allowed us to identify a range of views that would not have been fully captured by using the questionnaire alone. The data analysis involved the construction of the chains of evidence that grouped quotes from each group thereby identifying attitudes to IT-related degrees and prospective careers (Beaudry and Pinsonneault, 2005). The questionnaire data (Phase 3) were collated and analyzed using descriptive statistics. Descriptive statistics were used to provide a simple summary on the measures taken. This approach supported the simplification of data into concise presentation (Trochim, 2006). While qualitative forms of analysis are more labor-intensive than quantitative schemes, they do offer a greater degree of explanatory power when a researcher is investigating the meaning behind a user's actions (DeSanctis & Poole, 1994), which is an advantage when conducting this type of exploratory study. In keeping with the abductive approach, analyzed data was compared to theoretical premises throughout the research cycle to support the "back and forth" nature of data collection and theory building (Kovács & Spens, 2005). The next section outlines the theory matching phase.

4. Theory Matching

We noted an unplanned but highly impactful consequence of collaborative intervention activities. While it was expected that students would hold individual mental models with respect to choosing third-level courses, there was also a group mental model that formed when workshop participants began to exchange views in their groups. Engaging the students in the collaborative interventions resulted in a shared understanding developing swiftly among the students. At the conclusion of the first collaborative intervention, the researchers undertook some preliminary theory matching in order to find an explanation for this phenomenon (Kovács & Spens, 2005). Theory matching (or "systematic combining") involves alternating between theory, observations and analysis in order to identify the best theoretical explanation for the phenomena under study (Dubois & Gadde, 2002). Theories such as Expectancy-Value Theory (Eccles, 2009; Wang & Degol, 2013), Shared Mental Model (SMM) Theory, and Stakeholder Theory (Donaldson & Preston, 1995) were identified and entertained as potential explanators. As described by Mohammed et al. (2010), SMMs are organized knowledge and mental representations shared by humans about their environment. While often used in team-based research, SMM theory provided a frame to comprehend the shared understanding that developed among the intervention participants. The students must research and select third-level courses they wish to undertake. While the selection of

these courses is individual, researching options typically involves the student engaging in a reflective consulting process with fellow students, friends, family, teachers and third-level educators. This cohort acts like a team in many respects, needing to coordinate activities and share knowledge. Much like the decision situation described by Cannon-Bowers, Salas & Converse (1993, p222) where the "final decision authority is retained by a single individual, the team functions to provide the decision maker with assessments and information that are crucial to the situation." The development of shared understanding amongst a cohort can address the often limited or incomplete representations that a student might have of a particular education or career path option. In the case of IT education and careers, these limited or incomplete representations relate primarily to gender stereotypes, awareness and ability. The collaborative intervention designed and tested here created an environment in which shared understanding could develop swiftly between students, teachers and third-level educators. As such, SMM theory (Cannon-Bowers et al., 1993; Jonker, van Riemsdijk & Vermeulen, 2011) was found to be a good fit to explain the rapid understanding that developed amongst intervention participants. After researching SMM theory, the researchers undertook additional workshops and began to develop a picture of how the collaborative interventions disrupted and provided an opportunity to investigate inaccurate existing SMMs (relating to gender stereotypes, awareness and ability) amongst students, teachers and third-level educators in order to better support student decision-making with respect to IT education and careers. The interventions worked towards dispelling inaccurate SMMs on gender, awareness and ability. While SMM theory provided an effective lens to view workshop interventions, the context also required some reconsideration of the key aspects associated with SMM. The next section outlines SMM theory as applied by this study.

4.1 Shared mental models

Mental models are the mechanisms by which humans reason using possibilities compatible with the premise at hand and their own general knowledge (Johnson-Laird, 1983). Shared mental model (SMM) theory as developed in social psychology has been frequently employed to explain how teams interact and perform tasks (Cannon-Bowers et al., 1993; Jonker et al., 2011). SMMs may be defined as "the organized knowledge that members shared about things like the task, each other, goals and strategies" (Espinosa, Kraut, Slaughter, Lerch, Herbsleb & Mockus, 2002, p. 426). SMM theory is a straightforward one: team performance will be better if members have a shared understanding of the team and the task at hand (Stout, Cannon-Bowers, Salas & Milanovich, 1999). Existing research has highlighted the existence of different types of shared mental models such as technology/equipment, job/task, team interaction and team (Cannon-Bowers et al., 1993). Given the variety of SMMs possible, establishing an accurate and similar SMM amongst team participants is not a straightforward task. Mathieu, Heffner, Goodwin, Salas & Cannon-Bowers (2000) proposed that team mental model convergence and task mental model convergence predicted team process quality and team performance quality. They further noted that while convergence of mental models can positively impact process and performance, this convergence does not necessarily mean the SMM is accurate. Cannon-Bowers et al., (1993) note that SMM theory does not imply identical mental models amongst participants but rather compatible models. However, SMMs do have the potential to encourage conformity in thinking and, thus, reduce decision quality (Kellermanns, Floyd, Pearson & Spencer, 2008). The issue of similarity and accuracy is one which arises frequently in relation to SMM (Lim & Klein, 2006; Mathieu et al., 2000). According to Mohammed et al., (2010), while similarity has received considerable attention in existing research, accuracy has been under-served. Furthermore, re-setting an inaccurate SMM that is firmly entrenched requires intervention (Mohammed et al., 2010).

While the majority of SMM research focuses on traditional team work structures (Kellermanns et al., 2008; Mohammed et al., 2010), we argue that the participants concerned with greater female inclusion in IT have a lot in common with such teams. In a similar way to traditional work teams, participants hold individual, expert information that needs to be disseminated and accepted. Therefore, communication and coordination are critical functions. In addition, the goal is to improve decision-making. To achieve the objective of higher representation of females in IT, an accurate SMM needs to be established amongst participants and their peers. The collaborative interventions served this purpose while also moderating the negative impact that perceived genderization, lack of awareness and perceived lack of ability has on SMMs. Students, teachers and third-level educators were participants in and recipients of the SMM that resulted from the collaborative interventions. The following section outlines the findings from the interventions.

5. Results

5.1 Pre-presentation

At the start of each intervention workshop, the Six Thinking Hats exercise and the theme were explained. Students were assigned into groups of four participants and they were provided with materials to construct each hat. After the hats were constructed, each team wore a single colored hat for eight minutes and recorded responses based on the color and theme associated with the hat. Initially, students wore the blue hat to clarify the objective of the exercise and capture initial reactions to the idea of a career in the IT field. In general, responses were predominantly focused on technology, career prospects, financial rewards and the perception of the field as "boring." Once this initial phase was complete the students commenced the brainstorming exercise in earnest. First, the students wore the **white hat** and recorded known facts on the topic. Students' responses indicated that they recognized the pervasiveness of IT in everyday life and the buoyancy of the job market. Some students mentioned the importance of computers "to do work." Noticeably, a number of responses referred to specific technologies such as the Internet, gaming and the "use of advertising on the web."

White Hat (Facts)	**Green Hat (Ideas)**	**Yellow Hat (Positivity)**
" we need computers to work"; "lots of job opportunities"; "you have to know computers"; "make loads of money"; "used in every job"; "in demand"; "rapidly evolving"; "websites, games, advertising use computers".	"phones"; "creating new technology"; "using computers to make software"; "fixing computers"; "website design"; "programming"; "game design"; "software development"; "making software"; "advertising".	"good money"; "success"; "interesting job"; "an enjoyable job"; "not many women in technology"; "job opportunities"; "lots of job opportunities"; "good pay"; "up-to-date on latest technology"; "large and growing demand"; "used in every job"; "travel".
Red Hat (Emotions)	**Black Hat (Criticisms)**	**Blue Hat (Organisation and Prioritisation of ideas)**
"boring"; "repetitive"; "numbers"; "maths"; "interesting"; "uneducated about it"; "for boys career-wise"; nervous"; "lost"; "uneducated"; "insecure"; "nice option"; "smart"; "not interested"; "confused"; "inadequate"; "men"; "technical"; "nerd"; "sitting in front of a computer".	"stressful"; "boring"; "does not sound that fun"; "hard"; "confused"; "challenging"; "not a lot of girls do it"; "people may excel more than you"; "unhealthy"; "inside all the time"; "unfulfilling"; "stuck on computer"; "less able to enjoy technology at home"; "no human interaction".	"boring"; "money"; "computers"; "there are jobs"; "Information technology".

Table 3. De Bono's Thinking Hat Illustrative Student Responses (Phase 1 – Results from Qualitative Data Analysis)

Second, using the **green hat** the students were asked to identify opportunities afforded by the IT field. During this phase, students specifically mentioned mobile phones, computers and software and "making" or "programming software." Third, with the **yellow hat** the students were asked to identify the benefits of a third-level degree programme in IT. Students revealed that they associated opportunities in IT with the possibility of earning a high salary or "good pay." Although students were asked to be positive during the yellow hat phase, a number of them mentioned that there are "not many women in technology." Fourth, the students were asked to wear the **red hat** and provide their "gut reactions" to the idea of undertaking an IT degree. At that point the responses from the students became quite negative. The red hat allowed the students to identify and explore their individual and seemingly shared concerns such as feelings of inadequacy, ill-preparedness, nervousness and the idea that IT practitioners spent a lot of time working in front of a computer. They suggested that working in IT required a person to be "technical," "smart," and a "nerd." Similar responses were recorded when groups used the **black hat** to identify risks associated with third-level college programmes and careers in IT. There was a common perception that working in technology meant one would be "inside all of the time" with "no human interaction" and "stuck on a computer." Finally, each group used the **blue hat** to prioritize their list of highlights; essentially building the groups shared understanding of the key takeaways from their discussion. The blue hat lists reflect the ideas that had been discussed during the previous five phases. Written responses for each hat were collected and are synthesized in Table 3. Noticeably, discussion across the groups promoted the use of a common vocabulary when considering the theme of opportunities for females in IT.

The perception that IT is male-dominated also emerged as a shared theme when students were asked to identify risks. Collectively, SMMs were established by each group based on their discussions. These SMMs were comparable across groups indicating widespread consensus in terms of building shared understanding. While these students had a good understanding of the importance of the field (white, green and yellow hats), they had difficulty picturing themselves studying, working, and thriving in the IT field (red and black hats).

5.2 Post-presentation questionnaire administered to students

Following the six hats session, as part of phase 2, we shared information about an IT-related degree and IT career opportunities. A questionnaire was then administered to students in phase 3. The post-presentation questionnaire questions are presented in Table 2. Answers for all questions were captured using five-point Likert scales. The questionnaire consisted of ten questions (Q1-Q10) and a final question to allow respondents the option to comment and expand on their answers to Q1-Q10.

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Mean	2.6	3.0	2.7	2.9	3.1	3.5	2.8	3.2	3.1	3.2
StDev	1.24	1.11	1.04	1.33	1.08	1.24	1.08	1.01	1.12	1.07

Table 4. Mean and Standard Deviation for Survey Questions

In total, there were 109 completed questionnaires. Descriptive statistics for Q1-Q10 are presented in Table 4 and the overall distribution of answers obtained for Q1-Q10 is presented in Table 5. On the basis of the mean scores (Table 4), while students appear to feel that they have a good understanding of third-level IT offerings (Q1) and that girls are interested in IT (Q3), These results are supported by the findings from the phase 1 Six Hats exercise, data collected from the teams during the white, green and yellow hat phases illustrated the students shared a good understanding about IT degrees available to them. The red hat, which represents emotion, identified the uncertainties and insecurities felt by these students, these are reflected in comments such as "IT is for boys," "IT is for nerds," and "I need to be good at math." These feelings are well supported in the survey data. Students agreed that third-level IT programmes are geared towards males (Q4), that a person undertaking an IT programme must be good at math (Q7). They felt they did not know enough about IT graduate salaries (Q6). However, they disagreed with the statements that all IT graduates became programmers (Q8) and that an IT programme would be too challenging for them personally (Q10). The standard deviations reported for each question suggest that there is high agreement amongst respondents, with Q4 showing a deviation of 1.33.

ID	% of respondents per scale				
	5 (Strongly Disagree)	4 (Disagree)	3 (Neutral)	2 (Agree)	1 (Strongly Agree)
Q1	9.2%	11.9%	29.4%	25.7%	23.9%
Q 2	12.8%	16.5%	38.5%	24.8%	7.3%
Q 3	3.7%	20.2%	35.8%	27.5%	12.8%
Q 4	15.6%	19.3%	17.4%	32.1%	15.6%
Q 5	8.3%	32.1%	27.5%	25.7%	6.4%
Q 6	25.7%	29.4%	22.9%	13.8%	8.3%
Q 7	10.1%	13.8%	33.0%	35.8%	7.3%
Q 8	10.1%	26.6%	36.7%	22.9%	3.7%
Q 9	11.0%	22.9%	33.9%	23.9%	8.3%
Q 10	10.1%	32.1%	30.3%	22.0%	5.5%

Table 5. Percentages of post-presentation attitudes on the ordinal scale (1-strongly agree, 2-agree 3-neutral, 4-disagree, 5-strongly disagree)

Post-presentation, students were asked if they were interested in pursuing an IT qualification (Q2). On average, respondents were neutral when it came to the prospect of a third level IT qualification (mean score: 3.0). Over a third of

respondents (38.5%) were ambivalent, while nearly 30 percent (32 respondents) were opposed or strongly opposed to undertaking an IT college course. Less than a third of the sample expressed interest in an IT qualification (Table 5). The survey findings strongly support the results of the red and black hat discussions in Phase 1, students articulated that had difficulty picturing themselves studying, working and thriving in the IT field.

5.3 Gender

Two questions in the post-presentation questionnaire related to gender (Q3, Q4). First, students were asked whether they thought girls were interested in IT. Over a third of students felt that girls are interested in IT (40.3%), with only 23.9 percent expressing the opposing view that girls are not interested in the area. However, with 35.8 percent of respondents unsure, the engagement of females in IT is a live issue. Second, students were asked whether they felt IT courses were geared towards male students. Nearly half of respondents think IT courses are focused towards males (47.7%). The results from these two questions suggest that while female students think girls are interested in IT courses, they perceive IT courses as catering specifically to male students. This view is well supported by the qualitative data. This sentiment was explicitly called out by all of the student teams in Phase 1 during the red hat (emotions) and black hat (criticisms) discussions. This perspective is supported by several respondent comments such as "why do people think men are the only ones good at IT?"; "I definitely feel like IT is geared towards male students. There is an unfair stigma against girls and IT. Many people assume girls are incapable of succeeding in such an area" and "females should be shown that IT is not a man's career."

5.4 Awareness

Several questions within the post-presentation questionnaire focused on awareness of IT qualifications and careers. Results indicate that nearly 50 percent of respondents had good awareness of third level IT qualifications (Q1) indicating a reasonable level of understanding amongst this cohort of young females, though 21 percent reported poor awareness of third level options. While a mean score of 2.6 suggests that there is awareness of IT courses, 32 students (29.4%) reported a neutral attitude to awareness which is a significant figure. In phase 1 during the red hat discussion, a number of the teams said that they felt "uneducated" about educational opportunities in IT and prospective IT careers. Several respondents suggested measures that would increase awareness of IT qualifications, such as increased promotions. A popular suggestion was to increase the teaching of IT and IS subjects at elementary and high school levels (known as primary and secondary school) in Ireland so that students have greater exposure to the IT field at an earlier stage in their academic careers.

In relation to IT industry salaries, results indicate that students did not feel that they possessed enough information (Q6). Only 22.1 percent (strongly agree and agree) felt they had been provided with sufficient salary data. Interestingly, during the white hat discussion in phase the notion that IT professionals "make lots of money" was suggested by some of the teams. By contrast, 55.1 percent of surveyed students (strongly disagree: 25.7%; disagree: 29.4%) were not satisfied with salary information. One student recommended that educators should "say more about the salary and show videos about the jobs that you could possibly do."

Respondents were similarly dissatisfied with IT career path information (Q5). Only 6.4 percent of respondents felt that they were familiar with IT career opportunities. By comparison, 40.4 percent (44 students) were unhappy with their knowledge of diverse IT roles in industry. Taken together, it appears that high school students do not know enough about IT careers and salaries. This finding was supported by student comments, with one respondent noting that "I was very interested in the IT course but I still don't really know what the people actually do" while another asked for presenters to "explain about jobs that don't involve sitting at a computer." An interesting point raised by one student was that teachers tended to focus on careers other than IT.

There was uncertainty among students when it came to roles of IT graduate involving programming (Q8). Survey data illustrates the uncertainty that students experience on this matter, with 40 respondents (36.7%) unsure of this point (mean score: 3.2). Only 10.1 percent were sure that IT careers offered more than just traditional computer programming/coding positions. Overall, only 36.7 percent of students indicated that they knew coding roles were not the only career paths. With respect to relevant information (Q9), only 32.2 percent of respondents felt that they had sufficient access. Over a third of students were not happy with their current access to IT course and career information (33.9%). A further 37

students (33.9%) were noncommittal with respect to information access. This uncertainty and lack of information is supported by the qualitative data uncovered in Phase 1. During the red hat (emotion) and black hat (criticism) discussions most of the groups talked about IT careers using negative language e.g. "stuck on a computer all day," "stressful," "boring," with "no human interaction." While some of the teams mentioned computer coding/programming and building websites, the data illustrated the lack of information and fundamental understanding of the diverse roles and opportunities in the IT field and in IT-related career paths.

5.5 Ability

Students were also asked two questions focusing on ability (Q7, Q10). Students were asked whether they thought they needed to be good at mathematics in order to pursue a third level IT qualification and career. Again, a significant number of respondents (47) viewed mathematical ability as critical to undertaking further education and a career in IT (43.1%). A third of respondents were unsure as to whether mathematical ability was a necessity (33%). Only 23.9 percent of respondents did not think mathematics was a key requirement for undertaking a third level IT course. The emphasis and need to be good at math is well supported in Phase 1, all of the teams referred to the need to be good at math to excel in IT.

Students were also asked whether they thought an IT course would be too challenging (Q10). Only 27.5 percent of respondents considered a third level IT course too much of a challenge. By comparison, 42.2 percent did not perceive an IT course as being too difficult for their skillset. Again, almost a third of respondents (30.3%) were unsure. In Phase 1 while the need to be good at math was highlighted by several groups, there was a sense that IT was "hard" and "challenging." The student teams seemed to question if they had the skills "to be good at computers/IT." This could be characterized as a fear of the unknown and a lack of confidence in their abilities. Several students commented on the limited exposure to technology at high school and the need to introduce coding courses into the local community.

6. Conceptual Model

As part of the abductive research approach (see Figure 3), theoretical suggestions are proposed to explain the role of SMMs in supporting decision quality and the intervention role of the #MakeITWork programme. Drawing on existing research and data gathered, the researchers define constructs and relationships in the form of theoretical propositions. Figure 4 presents the conceptual model and associated propositions.

Analysis of data gathered indicates the presence of a SMM on the part of females with regards IT education and careers. SMMs are a powerful contributor to decision-making. However, if the prevailing SMM is inaccurate and incomplete (as identified in the case of our collaborative intervention participants) the decision-making process will be inherently flawed. Therefore, SMM is introduced as a construct in our model.

The survey showed that almost sixty percent of this cohort of female high school students either are not sure or are not interested in IT. This was supported by evidence that almost half felt that IT was solely targeted at males. Thus, we propose the following proposition:

P1: Perceived genderization of IT education and careers has a negative effect on accurate shared mental models

Data analysis strongly supports the lack of awareness around IT among this student group with only 6.4 percent and 22.1 percent completely satisfied with the information about IT roles and salaries respectively. Existing literature supports the lack of awareness and understanding among young women about the variety of IT careers (Anderson et al., 2008; Ridley & Young, 2012). Therefore, the researchers introduce awareness as a construct and posit the following proposition:

P2: Lack of awareness of IT education and careers has a negative effect on accurate shared mental models

Data analysis indicates that perceived lack of ability is an important factor that contributes to students SMM. Over 40 percent of participating students perceived mathematical competency as critical to pursuing a career in IT, while 30 percent were unsure whether they would be capable of succeeding in a third-level IT course. Our findings support existing research highlighting the lack of confidence in technical ability remains a challenge for females attending high school

(Eccles, 2011; Fisher et al., 2015). Thus, we introduce ability as a construct and propose the following proposition:

P3: Lack of confidence in IT ability has a negative effect on accurate shared mental models

The purpose of programmes such as #MakeITWork is to facilitate more informed, effective decision-making with respect to third-level education and future career choices. As such, decision quality refers to the caliber of the decision made by the decision-maker (Raghunathan, 1999). While similarity of SMMs has been studied with respect to decision quality (Kellermanns et al., 2008), the researchers propose that in the context of student education and career decisions, it is the accuracy of the SMM that is critical. Greater convergence with respect to shared knowledge is not the goal but rather a true understanding of the circumstances. Accuracy means an SMM that is free from error and reflects the true state of the given context (Mohammed at al., 2010). SMM accuracy has been positively related to decision making (Lim & Klein, 2006). Therefore, the researchers introduce decision quality as a dependent variable and posit the following proposition:

P4: Accurate shared mental models have a positive effect on decision quality.

Analysis of data gathered via the #MakeITWork programme suggests that the workshops acted as an intervention mechanism to temper the negative impact that entrenched genderization, awareness and ability beliefs reflected in the SMM communicated by these female high school students. Thus, the researchers insert interventions as a moderating construct and propose the following proposition:

P5: Collaborative interventions will moderate the negative effect of perceived genderization, lack of awareness and lack of confidence on shared mental model accuracy.

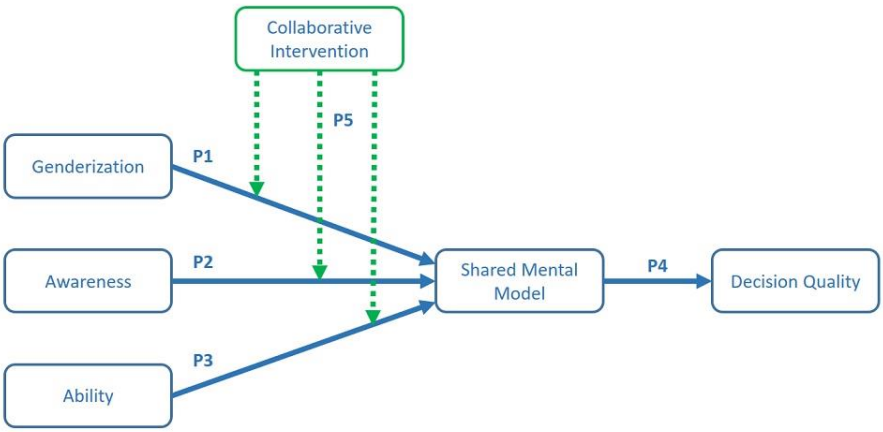

Figure 4. Conceptual Model - Establishing a SMM for Female Participation in IT

The final model (Figure 4), via five theoretical propositions, presents a theory for how collaborative interventions act as a moderator to ensure accurate SMMs and, consequently, better decision quality. Previous studies examine the factors influencing IT gender gap separately, such as individual, family and social factors (e.g. Anderson et al., 2008; Drabowicz, 2014; Fisher et al., 2015), within the model perceived genderization, lack of awareness and lack of confidence in ability are individual-level constructs work together to enable a SMM (group-level construct) to emerge. This group-level construct is necessary to capture a more holistic view of the collective knowledge shared by participants.

In future studies, further elaboration is necessary in order to operationalize the conceptual model with respect to hypotheses and construct measures. Following Morgeson & Hofmann (1999), measures for group-level constructs would be framed in collective terms with the individual taking an informant role.

7. Conclusions

This study contributes to the cumulative body of research on female engagement in IT. Using SMM theory as a theoretical lens, the purpose of the #MakeITWork programme was to investigate young females' understanding of IT-related degree programmes and the career opportunities afforded to IT graduates. Drawing on prior studies, our research leverages the factors that influence young womens' decisions culminating in a shared understanding of the perception of IT as an area of study and a potential career choice. This was achieved by designing, piloting and assessing a novel collaborative intervention workshop approach.

It is important to consider the limitations of this study. With any empirical study there are several limitations that should be considered when interpreting the findings. The study uses three schools in the south of Ireland and a total of 109 students. As illustrated in Figure 1, this study focuses on three specific issues (i) awareness; (ii) gender and (iii) ability. These issues do not represent an exhaustive list with respect to female engagement. There are likely other issues that contribute to the issues surrounding the decreasing number of female students undertaking IT programmes. In addition, the study has not (to date) been piloted in boys-only or mixed high schools. In order to illuminate the entire landscape, there is an opportunity to explore how boys and mixed schools experience the issues of awareness, gender and ability in relation to IT. We recognize that attention must be given to high school based IT educators. IT has been recently introduced to the high school teaching curriculum in Ireland. Up to now teacher(s) with an interest in IT took responsibility for IT education in their respective schools. Understanding the awareness of teachers in terms of gender and ability would offer valuable insights, particularly in terms of further appreciating the implications of assumptions or misconceptions held by this cohort about females in IT and the effect that this may be having on students. In support of this, the researchers commenced a new set of interventions in 2016 to bring together high school teachers, career guidance counsellors and industry professionals. The objective of these collaborative interventions is to develop an accurate complete SMM between participants building a common understanding and common language around the opportunities for females with IT skills in a modern global economy.

This study indicates that female students perceive IT as outside of their comfort zone professionally, socially and academically. While students are generally aware of third-level IT qualifications they do not have sufficient awareness of the diversity of professions and associated salaries. This implies that while students have access to information, it is not the right type to suit their specific requirements. While a significant number of female students believe that girls are interested in IT (40%), nearly half of those surveyed think that the IT field and third-level qualifications are geared towards males. Close to half (43%) consider mathematical ability critical for an IT qualification. However, 42% of those surveyed do not think an IT qualification would be too challenging to undertake which is surprising given the other results. Across the entire set of survey responses, there was a significant number of respondents who were unsure/neutral on several aspects of IT education and careers (for Q8, 36.7% were unsure whether all IT graduates became programmers). This implies that female students could not answer questions with any degree of confidence and most likely lacked the access to information that would inform them. While the #MakeITWork programme focused on dispelling inaccurate SMMs held by female students with regard to IT education and careers, analysis of the survey data indicates that it did not successfully address all misconceptions. It is important to note that some SMMs takes longer to effect than others and not all mental models are amenable to alteration (Jones et al., 2011). Following Cannon-Bowers et al., (1993), our review of the literature and the selection of SMM as a theoretical lens, evidence points to a larger cast of actors that contribute to the SMM held by students. The #MakeITWork programme participants were limited to female students, their teachers and third-level educators. Family, friends and mass media were not included as participants. However, these stakeholders likely have a significant influence on the SMM. This study is a first step in adapting SMM theory to this particular context. In Figure 4, we have introduced a new construct, namely shared mental models, to account for the low female participation in IT. Further research will leverage SMM Theory to further elaborate on the role of this wider group of stakeholders as a means of better understanding young females' attitudes to IT-related degrees and subsequent career opportunities.

There are a number of key recommendations for educators/recruiters and those employing IT graduates. The diversity of IT roles needs to be better communicated to female students. The message that while mathematical ability is important; lower competency does not preclude someone from succeeding in the field. In order to properly address the first two implications, educators need to tailor marketing material and customize presentations to better convey the positive message and dispel old-fashioned views of the field. Educators at second and third level, and indeed perhaps as early as elementary school, need to collaborate to deliver an effective, positive and consistent message to students. Researchers,

educators and practitioners need to encourage a more accurate, inspirational, varied representation of women in IT in media so that young females begin to identify themselves with the field. For example, the way females involved in IT are portrayed in popular TV shows and films does little to dispel the misconceptions. While female representation is welcome, it tends to not be very varied with respect to the level (characters are usually highly experienced or gifted when it comes to technology), organizational role (typically, programmer, analyst or hacker) and location (mostly working alone in a poorly lit office).

The study findings have two main implications for research. First, this study supports existing research (Anderson et al., 2008; Fisher et al., 2015), which posits that female students perceive the IT field as: (i) being geared towards males (Whitney, Gammal, Gee, Mahoney & Simard, 2013); (ii) requiring high levels of mathematical aptitude (Anderson et al., 2008; Leever et al., 2002; Leiviskä, 2010) and (iii) anti-social or un-dynamic (von Hellens et al., 2000; Margolis & Fisher, 2003). In addition, this study upholds the view that female students are not receiving the right message from educators and IT practitioners (Kahle & Schmidt, 2004). Second, this study proposes, trials, and assesses a novel collaborative intervention approach, in the form of the #MakeITWork programme, for addressing the key misconceptions held by female students in relation to the field and develops an accurate SMM to support a better understanding of IT opportunities among female high school students. This intervention approach supports interactions with teenagers in a meaningful, informal way that facilitates a natural, non-pressurized environment wherein students felt comfortable expressing their often deeply-held views on the topic of female participation in IT. The interventions allowed for the development of an accurate SMM amongst participants without forcing identical mental models. This point is critical as the purpose of the collaborative intervention workshops was not to force one view of IT education and careers on students but rather recalibrate the existing, inaccurate SMM that appears to be curtailing student decisions. The decision to pursue an IT-related education and career is individual but the perception that a student has about IT arises from a group of actors (students, friends, family, teachers, third level educators and media). An individual mental model may also likely be incomplete and, as such, may depend on the prevailing SMM to fill the gaps. Therefore, recognizing that there is a SMM at work allows for novel approaches to be proposed and applied to ingrained biases with regards IT. The model proposed in this article (Figure 4) is one such novel approach. The goal is to facilitate students making an informed, unbiased decision with regards IT education and careers. The IT domain is not for everyone but potential participants should not feel they are excluded on the basis of gender stereotypes, perceived lack of ability and/or limited awareness.

In Phase 2 of the study, the researchers used knowledge sharing (KX sessions) to disseminate information about opportunities in IT. Nonetheless, the survey findings illustrated that there are considerable misconceptions about the IT field. This may be one indicator that these feelings are deeply entrenched among this population of female students. While female students can see the benefits of engaging in the IT field, it is from a position of theory rather than intended practice. Given the complex contextual situation and the number of stakeholders, i.e. students, peers, teachers, parents, industry role models, in which qualification and career choices are made, researchers need to better understand existing mental models in order to build accurate collaborative SMMs that will better support females in their decisions around IT qualifications and subsequent careers. We propose a conceptual model with associated propositions that incorporates existing theory (SMM) as a mechanism by which to explain poor decision-making with respect to IT education and careers. We have contributed to theoretical development that is relevant to female inclusion in IT. In terms of application (Kovács & Spens, 2005), this collaborative intervention approach provides practical assistance to those engaged in promoting IT education and careers.

On a final note, there is a problem of negative perception that has grown steadily over the past twenty years. The bigger challenge is to identify and understand the factors that contribute to this negative perception. We have identified the challenges of the existing shared mental model (SMM). In future research, we hope to understand the factors that have led to more negative female perceptions of IT in 2019 than in the late 20th Century. This will be explored by pursuing regular, ongoing interventions beyond a single #MakeITWork event. A longitudinal approach will provide researchers, educators and IT practitioners with the opportunity to explore genderization, awareness, and ability, potentially identifying additional factors, to identify and tailor measures that can begin to address low female participation. The IT field is growing and accepting that a large part of the world's population is unwilling or deterred from entering the IT industry is untenable (Chhabra, 2014; Lev-Ram, 2014).

References

Accenture (2017). "Girls in STEM, Powering Economic Growth: Attracting more Women in Science and Technology", https://www.accenture.com/t20170905T101544Z__w__/ie-en/_acnmedia/PDF-60/Accenture-Girls-in-STEM-Research-Report-2017-online.pdf. Last Accessed Nov 2nd 2018.

Adya, M. & Kaiser, K. M. (2005). Early determinants of women in the IT workforce: a model of girls' career choices. *Information Technology & People*, 18(3), 230-259.

Ahuja, A. (2002). Women in the information technology profession: a literature review, synthesis and research agenda. *European Journal of Information Systems*, 11(1), 20-34.

Ahuja, M. K., & Thatcher, J. B. (2005). Moving beyond intentions and toward the theory of trying: effects of work environment and gender on post-adoption information technology use. *MIS Quarterly*, 29(3), 427-459.

Anderson, N., Lankshear, C., Timms, C., & Courtney, L. (2008). 'Because it's boring, irrelevant and I don't like computers': Why high school girls avoid professionally-oriented ICT subjects. *Computers & Education*, 50(4), 1304-1318.

Aperian Global. (2017). Corporate Diversity Programs in 2017: What's Working & What's Not - Aperian Global. [online] Available at: http://www.aperianglobal.com/companies-making-diversity-programs-priority-2017/ Last accessed 10th Jun. 2018.

Ashcraft, C., Eger, E., and Friend, M. (2012). Girls in IT: The Facts. USA: National Center for Women in Information Technology (NCWIT). Available at: https://www.ncwit.org/sites/default/files/.../girlsinit_thefacts_fullreport2012.pdf Last Accessed March 3rd 2018.

Ashcraft, C., Eger, E., and Friend, M. (2016). Girls in IT: The Facts - 2016 UPDATE // See what's changed and what hasn't. USA: National Center for Women in Information Technology (NCWIT). Available at: https://www.ncwit.org/resources/women-tech-facts-2016-update Last Accessed March 3rd 2018.

Beaudry, A. and Pinsonneault, A. (2005). Understanding Users Responses to Internet Technology: A Coping Model of User Adaptation. *MIS Quarterly*, 29(3), 493-524.

Beise, C., Myers, M., VanBrackle, L. & Chevli-Saroq, N. (2003). An examination of age, race and sex as predictors of success in the first programming course. *Journal of Informatics Education Research*, 5(1), 51-64.

Beyer, S., Rynes, K., Perrault, J., Hay, K. and Haller, S. (2002). *Gender differences in computer science students*. Association for Computing Machinery SIGCSE Technical Symposium on Computer Science Education, Cincinnati, OH, 49-53.

Camp, T. (1997). The incredible shrinking pipeline. *Communications of the ACM*, 40(10), 103-10.

Cannon-Bowers, J. A., Salas, E., & Converse, S. A. (1993). Shared mental models in expert team decision making. In N. J. Castellan (Ed.), Individual and group decision making (pp. 221–246). Hillsdale, NJ: Lawrence Erlbaum Associate.

Carr, A., Durant, R. & Downs, A. (2004). Emergent strategy development, abduction, and pragmatism: New lessons for corporations. Human Systems Management 23(2), 79–91.

Chhabra, E. (2014). Code Debugs Code Debugs The Gender Gap In Tech, Forbes Magazine. Available at:https://www.forbes.com/sites/eshachhabra/2014/10/30/code-debugs-the-gender-gap-in-tech/#46a828df461c Last accessed Nov 27th, 2014.

Cisco Systems (2004). Gender Diversity Initiative. http://certmag.com/women-in-it-ciscos-gender-diversity-initiative/ Last accessed Nov 27th 2014.

Clayton, K., Beekhuyzen, J., & Nielsen, S. (2012). Now I know what ICT can do for me!. *Information Systems Journal*, 22(5), 375-390.

Cosgrove, P. (2015). Why Women are your Future. [online] CPL. Available at: https://www.cpl.ie/Library/CPL/cpl.ie/Employers/Future%20of%20Work/Why-Women-Are-Your-future-Cpl-Future-of-Work-Institute.pdf. Last accessed 10th Jun. 2018.

Craig, A. (2015). Theorising about gender and computing interventions through an evaluation framework. *Information Systems Journal*, 26(6), 585-611. https://doi.org/10.1111/isj.12072

De Bono, E. (1985). Six Thinking Hats, Little, Brown and Company, Boston, USA.

DeSanctis, G. & Poole, M. S. (1994). Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. *Organization Science*, 5(2), 121-147.

Donaldson, T., & Preston, L. E. (1995). The stakeholder theory of the corporation: Concepts, evidence, and implications. *Academy of Management Review*, 20(1), 65-91.

Drabowicz, T. (2014). Gender and digital usage inequality among adolescents: a comparative study of 39 countries. *Computers & Education*, 74, 98–111. 10.1016/j.compedu.2014.01.016.

Dubois, A. & Gadde, L.E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, 55(7), 553–560.

Eccles, J. S., Barber, B. & Jozefowica, D. (1999). Linking Gender to Educational, Occupational, and Recreational Choice: Applying the Eccles et al. Model of Achievement-Related Choices, 153–91 in Sexism and Stereotypes in Modern Society: The Gender Science of Janet Taylor Spence. Washington, D.C.: American Psychological Association.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, 44(2), 78-89.

Eccles, J. (2011). Gendered educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *International Journal of Behavioral Development*, 35(3), 195-201.

Espinosa, A., Kraut, R., Slaughter, S., Lerch, J., Herbsleb, J., & Mockus, A. (2002). *Shared mental models, familiarity, and coordination: A multi-method study of distributed software teams*. ICIS 2002 Proceedings, 39.

European Commission (2013). Women Active in the IT Workforce. https://ec.europa.eu/digital-single-market/en/women-ict. Last accessed Aug 29th 2016

Eurostat (2014). Education Statistics - Share of women among tertiary students (science, maths and computing).http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&pcode=tps00063&language=en.Last accessed Nov 27th 2014.

Fisher, J., Lang, C., Craig, A. and Forgasz, H. (2015). *If Girls Aren't Interested in Computers Can We Change Their Minds*, European Conference on Information Systems, Completed Research Papers, Munster, Germany.

Gürer, D. & Camp, T. (2002). An ACM-W literature review on women in computing. ACM SIGCSE Bulletin, 34(2), 121-127.

Intel.com. (2016). Decoding Diversity: The Financial and Economic Returns to Diversity in Tech. [online] Available at:https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2016/07/Diversity_report_7.7.16_web-1.pdf [Accessed 10 Jun. 2018].

Johnson-Laird, P. N. (1983). Mental models: Towards a cognitive science of language, inference, and consciousness (No. 6). Harvard University Press.

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental models: an interdisciplinary synthesis of theory and methods. *Ecology and Society*, 16(1).

Jonker, C. M., van Riemsdijk, M. B., & Vermeulen, B. (2011). Shared mental models. In Coordination, organizations, institutions, and norms in agent systems vi (132-151). Springer Berlin Heidelberg.

Kahle, J. & Schmidt, G. (2004). Reasons women pursue a computer science career: Perspectives from women from a mid-sized institution. *Journal of Computer Science in Colleges*, 19 (4) (2004), 78–89.

Kellermanns, F. W., Floyd, S. W., Pearson, A. W., & Spencer, B. (2008). The contingent effect of constructive confrontation on the relationship between shared mental models and decision quality. *Journal of Organizational Behavior*, 29(1), 119-137.

Kennedy, J. (2014). Irish Gov aims to fill 44,500 Tech Jobs by 2018, Available at: http://www.siliconrepublic.com/careers/item/36148-irish-govt-aims-to-fill-44. Last accessed Nov 27th 2014

Kitzinger, J. (1995). Qualitative research: introducing focus groups. *BMJ*, 311(7000), 299-302.
Komori, M. (2017). Thematic Analysis [Online], Available at: http://designresearchtechniques.com/casestudies/thematic-analysis/. Last accessed Nov 30th, 2018.
Kovács, G. & Spens, K. M. (2005) Abductive reasoning in logistics research. *International Journal of Physical Distribution & Logistics Management*, 35(2), 132 - 144.
Leever, S., Dunigan, M. & Turner, M. (2002). The Power to Change is in our Hands. *JCSC*, 18, 2 December, 169-179.
Lev-Ram, M. (2014). The Global Talent Crunch. Fortune Magazine. Available at: http://fortune.com/2014/09/04/the-global-talent-crunch/. Last accessed Nov 27th, 2014.
Leiviskä, K. (2010). *Attitudes of Sixth Form Female Students toward the IT Field.* ACM SIGCAS Computers and Society, 40 (1), 34-49.
Lim, B. C. & Klein, K. J. (2006). Team mental models and team performance: A field study of the effects of team mental model similarity and accuracy. *Journal of Organizational Behavior*, 27(4), 403-418.
Margolis, J. & Fisher, A. (2003). Unlocking the clubhouse: women in computing. Cambridge, MA: Massachusetts Institute of Technology Press.
Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of applied psychology*, 85(2), 273.
Millar, J. & Jagger, N. (2001). Women in ITEC courses and careers. Organization for Economic Co-operation and Development (OECD). (2007). ICTs and Gender. http://www.oecd.org/dataoecd/16/33/38332121.pdf Last accessed Nov 30th 2018.
Mohammed, S., Ferzandi, L., & Hamilton, K. (2010). Metaphor No More: A 15-Year Review of the Team Mental Model Construct. *Journal of Management*, 36(4), 876-910.
Morgeson, F. P., & Hofmann, D. A. (1999). The structure and function of collective constructs: Implications for multilevel research and theory development. *Academy of Management Review*, 24(2), 249-265.
Noland, M., Moran, T., & Kotschwar, B. (2016). Is Gender Diversity Profitable? Evidence from a Global Survey. Peterson Institute for International Economics Working Paper No. 16-3.
Nonaka, I. & Takeuchi, H. (1995). The Knowledge-Creating Company. Oxford University Press, New York, NY.
Papastergiou, M. (2008). Are computer science and information technology still masculine fields? High school students' perceptions and career choices. *Computers & Education*, 51(2), 594-608.
Peirce, C. S. (1955). Philosophical writings of Peirce. Ed. by Justus Buchler. New York: Dover.
Raghunathan, S. (1999). Impact of information quality and decision-maker quality on decision quality: a theoretical model and simulation analysis. *Decision Support Systems*, 26(4), 275-286.
Remenyi, D. & Williams, B. (1995). Some aspects of methodology for research in information systems. *Journal of Information Technology*, 10, 191.
Ridley, G., & Young, J. (2012). Theoretical approaches to gender and IT: examining some Australian evidence. *Information Systems Journal*, 22(5), 355-373.
Siann, G. & Callaghan, M. (2001). Choices and barriers: factors influencing women's choice of higher education in science, engineering and technology. *Journal of Further and Higher Education*, 25 (1).
Stout, R. J., Cannon-Bowers, J. A., Salas, E., & Milanovich, D. M. (1999). Planning, shared mental models, and coordinated performance: An empirical link is established. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 41(1), 61-71.
Trauth, E.M., Nielsen, S.H. and von Hellens, L.A. (2003). Explaining the IT gender gap: Australian stories for the new millennium. *Journal of Research and Practice in Information Technology*, 35 (1), 7-20.
Trauth, E. M., Quesenberry, J. L., & Morgan, A. J. (2004). *Understanding the under representation of women in IT: Toward a theory of individual differences.* In Proceedings of the 2004 SIGMIS conference on Computer personnel research: Careers, culture, and ethics in a networked environment (114-119). ACM.
Trauth, E. M. (2006). Theorizing gender and information technology research. *Encyclopedia of gender and information technology*, 2, 1154-1159.
Trauth, E.M., Howcroft, D., Butler, T., Fitzgerald, B. & DeGross, J. (Eds.) (2006). Social Inclusion: Societal

and Organizational Implications for Information Systems. New York: Springer.

Trauth, E. M. (2013). The role of theory in gender and information systems research. *Information and Organization*, 23(4), 277-293.

Trochim, W K. (2006). Descriptive Statistics. Research Methods Knowledge Base [Online]. Available at: http://socialresearchmethods.net/kb/statdesc.php, Last accessed 16 August 2017.

von Hellens, L., Nielsen, S. & Beekhuyzen, J. (2004). An exploration of dualisms in female perceptions of IT work. *Journal of Information Technology Education: Research*, 3(1), 103-116.

von Hellens, L.A., Pringle, R., Nielsen, S.H. & Greenhill, A. (2000). *People, business, and IT skills: the perspective of women in the IT industry*, in Nance, W. (Ed.), Proceedings of the ACM SIGCPR Special Interest Group on Computer Personnel Research, Association for Computing Machinery, Chicago, IL, 152-7.

Wang, M.-T., & Degol, J. (2013). Motivational Pathways to STEM Career Choices: Using Expectancy-Value Perspective to Understand Individual and Gender Differences in STEM Fields. *Developmental Review* : DR, 33(4), http://doi.org/10.1016/j.dr.2013.08.001

Whitney, T., Gammal, D., Gee, B., Mahoney, J. & Simard, C (2013). Priming the Pipeline: Addressing Gender-Based Barriers in Computing, *Computer*, 46(3), 30-36.

Whitten, J.L., Bentley, L.D. & Dittman, K.C. (2004).Systems Analysis and Design Methods, (6th edition.), McGraw-Hill, Boston, MA, USA.

Winning, L. (2018). "It's Time To Prioritize Diversity Across Tech" [Online] Forbes.com. Available at: https://www.forbes.com/sites/lisawinning/2018/03/13/its-time-to-prioritize-diversity-across-tech/#279b916616f8, Last accessed 10th Jun. 2018.

Van Mannen, J. (1983). Reclaiming qualitative methods for organisational research, in Qualitative Methodology, J. Van Maanen, ed., London: Sage Publications, 520-526.

Victorian Curriculum and Assessment Authority. (2014). VCE Unit Completion Outcomes - 2013 - Information Technology. Melbourne: Victorian Government.

Authors Biographies

Dr. Gaye Kiely is a lecturer and researcher in Business Information Systems at Cork University Business School, University College Cork (UCC), Ireland. She is co-director of BSc. Business Information Systems at UCC. She holds a BSc in Business Information Systems (1998), an MSc (Research) on software lifecycles (2001), and a PhD on Global Virtual Team Coordination (2012). Her research interests have centered on global virtual software development teams, distributed collaboration, and coordination. Additionally, she has conducted research in the areas of software development methods and inclusion in the IT field. More recently, her research focus has turned to open data, collaborative work, and community sustainability.

Dr. Ciara Heavin is a Senior Lecturer in Business Information Systems at Cork University Business School, University College Cork, Ireland. Her research focuses on opportunities for using information systems (IS) in the global healthcare ecosystem and in digital transformation. As Co-Director of the Health Information Systems Research Centre (HIRSC), Dr. Heavin has directed funded research in the investigation, development, and implementation of innovative technology solutions in the health/healthcare domain. She has published articles in several top international IS journals and conference proceedings. Dr. Heavin coauthored two books with Daniel J. Power: Decision Support, Analytics, and Business Intelligence and Data-Based Decision Making and Digital Transformation.

Patricia Lynch is Department Manager and Manager of Placement Programme in Business Information Systems at Cork University Business School, University College Cork, Ireland. She completed her MComm at University College Cork.

Page intentionally left blank